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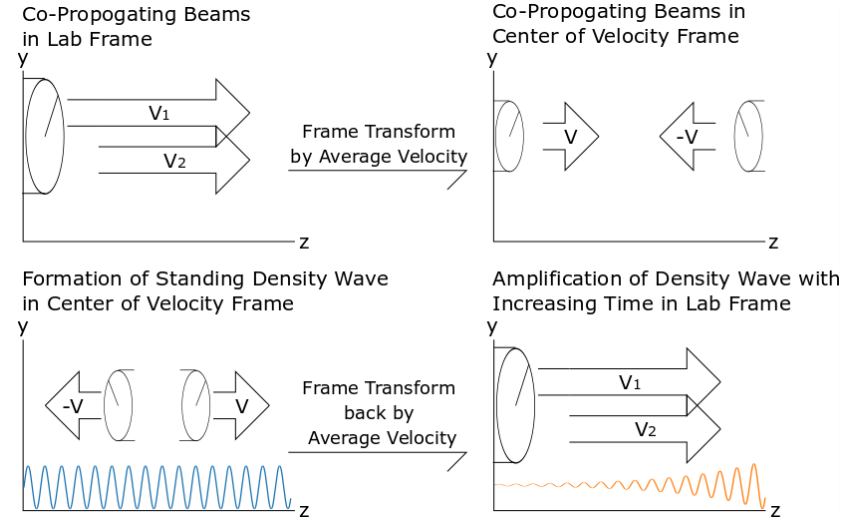
Ultra Wide Bandwidth Source Utilizing the Two Stream Instability

Derek Neben

8/2/2021

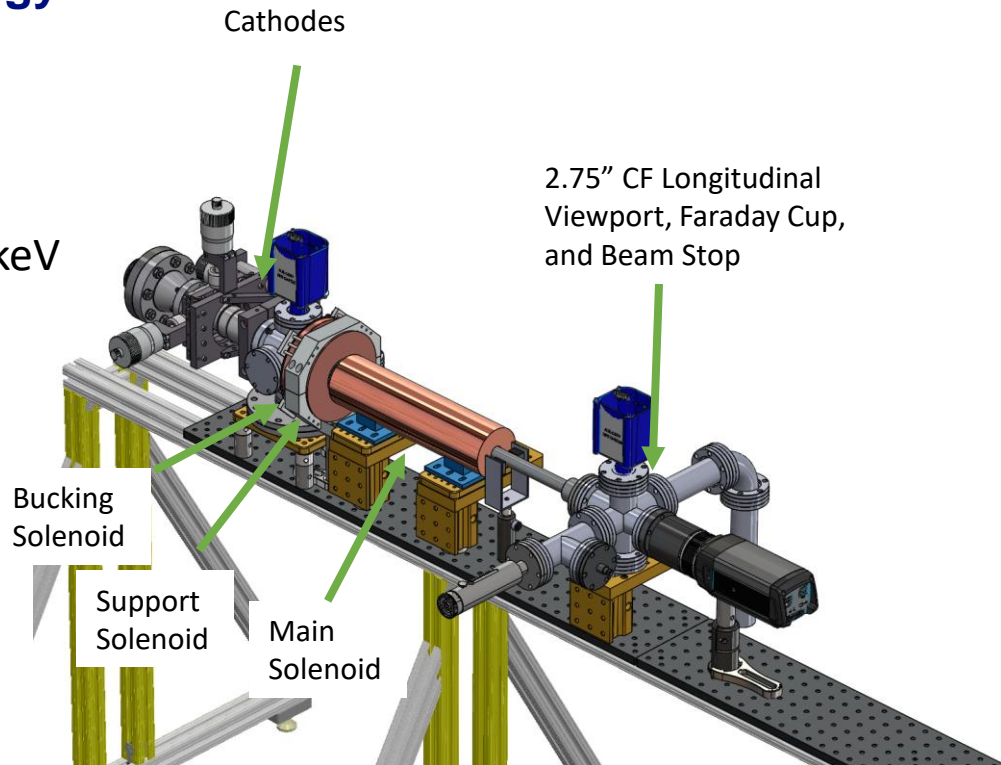
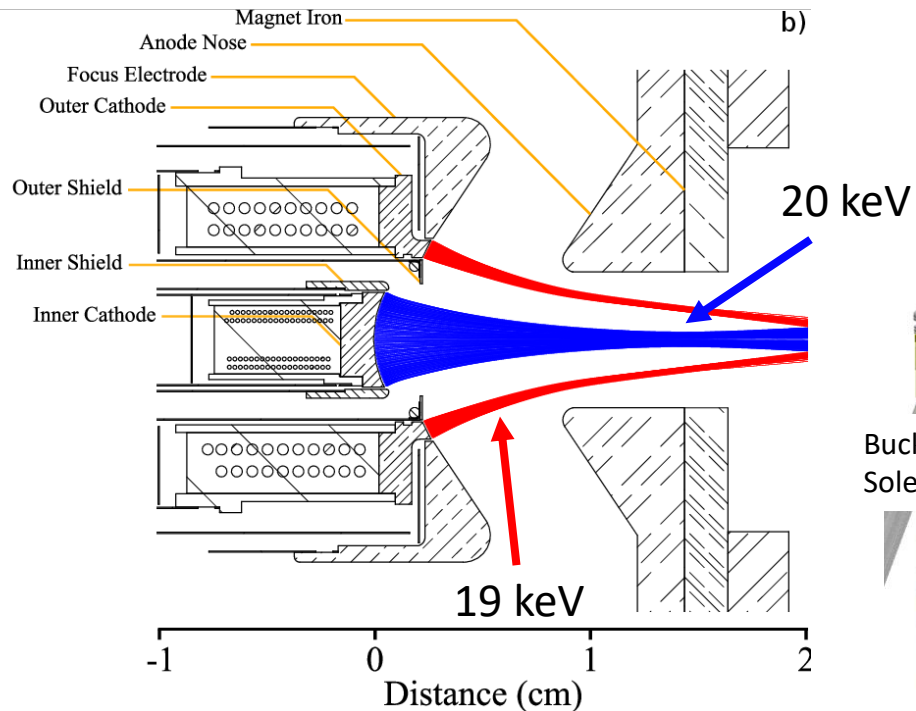
Overview of the Two Stream Instability

- The two stream instability forms when two intense and interacting beams (or plasmas) drift relative to each other.
- First used to generate RF radiation in 1949 [1] but was not competitive with triode technology in the MHz range.
- Contemporary demands for high frequency and high bandwidth makes the two-stream instability competitive with Traveling Wave Tube (TWT) commonly used in commercial and military applications.
- The frequency of the instability is sensitive to the velocities of the beams: $f \propto \frac{v_1 + v_2}{v_1 - v_2}$.



[1] A. Hollenberg, "Experimental observation of amplification by interaction between two electron streams," Bell Syst. Tech. J.28, 52 (1949).

Co-Axial Cathode Configuration to Generate Beams of Dissimilar Energy



Estimated Performance of Two Stream Instability Microwave Source

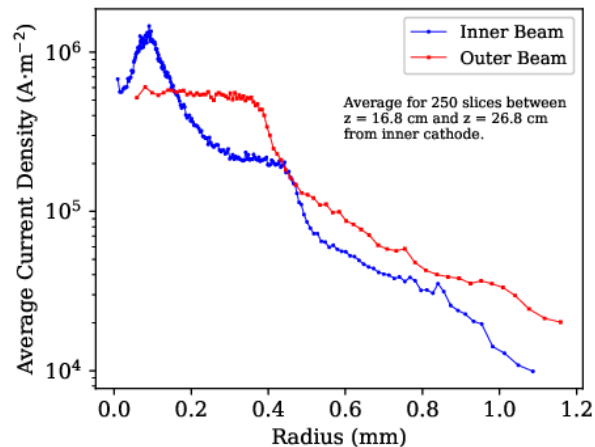
- One issue with a co-axial linear device is that the upper limit on the instability frequency is dictated by the beam radius if the beams are annular [2].
 - This problem was solved by our novel design, predicting good overlap of the beams in physical space.
- Potential for ultra-wide bandwidth in a linear device with estimated 1 dB/cm gain over 4.3-180 GHz [3].

[2] N. Yampolsky and K. Bishofberger, "Description of longitudinal space charge effects in beams and plasma through dielectric permittivity", arXiv:2102.08491 (2021).

[3] D. Neben, et al., "A co-axial electron gun to generate millimeter-wave RF using the two-stream instability" Rev. Sci. Instrum. 92, 053301 (2021).

Outer Cathode: **-19 kV**

Inner Cathode: **-20 kV**



Outer Cathode Potential (kV)	Inner Beam r95% (mm)	Outer Beam r95% (mm)	Total Beam r100% (mm)	Frequency (GHz)	Gain Length (dB/cm)
-15	0.54	1.08	1.14	4.3	1.0
-16	0.45	1.03	1.09	5.4	1.0
-17	0.45	1.00	1.06	7.5	1.0
-18	0.52	0.97	1.02	12	1.0
-19	0.74	0.94	0.99	30	1.0
-20	0.96	0.95	1.03	180	0.9